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# HYPERSONICS AND THE GLOBAL DISORDER

## DEVELOPMENTS IN GLOBAL MISSILE TECHNOLOGY AND ITS IMPLICATIONS

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WERNHER VON BRAUN - famously considered the father of modern missile technology – was the chief architect of the Nazi rocket programme, the American intermediate-range ballistic missile program, playing a crucial role in the development of the Saturn V super heavy-lift launch vehicle which would take the first man to the Moon in July 1969. The SS-Sturmbannführer played a critical role in the development of the Vergeltungswaffen (also known as Wunderwaffen) programme, which included the development of the world's first ballistic missile – the V2. When the first V-2 hit London von Braun remarked to his colleagues, *"The rocket worked perfectly except for landing on the wrong planet"*[1].

The space pioneer that von Braun was, wanted to commit himself and his research toward the development of technology for the peaceful purpose of expanding humanity's knowledge and capabilities: *"I aim for the stars, but I keep hitting London"*. But that technology – like so many others – ended up being militarised and used for warfare. A rocket that marked the beginning of the global race to space also marked the beginning of a whole new era of war-fighting, enabling man to kill others who may be halfway across the world. From the beginning of the cold war to the end, and well beyond it today, we have seen the continuous development of missile technology which involves sophisticated components such as its engine which usually have turbofans or ramjet forms of propulsions, its guiding and navigation systems which include several sensors and lasers, its targeting systems which are constantly worked upon to improve the accuracy of strikes, its flight control system and of course the warhead that it carries, which can be adjusted for both conventional and nuclear deployments.

Missiles present a definitive threat to every single actor involved. These platforms eliminate the need for a manned aircraft to penetrate enemy territory or enemy-held points of interest to drop ordnance and achieve mission objectives. Missiles can penetrate enemy defences with comparatively lesser chances of failure, and about zero casualty rates for the operators. Missiles also have the advantage of lesser maintenance, training, and logistic requirements than manned aircraft. Since the second world war, missile technology has been developed to the extent of being able to carry with it warheads with an explosive force of over a hundred times more powerful than

[1] Colorado Space Grant Consortium. (2006, September 19). Von Braun: Germany. Retrieved from Colorado Space Grant Consortium: https://spacegrant.colorado.edu/COSGC%Projects/Space/Rocket%History/Wernher%von%Braun

the Little Boy atomic bomb (15 kilotons of TNT) which was dropped over Hiroshima. Research and development have also enabled countries to assemble nuclear triad capabilities as deterrence measures. This triad includes ballistic missiles of varying ranges deployed in silos, aboard submarines, and on land-mobile launchers – including trucks and railcars – as well as nuclear munitions on-board strategic attack aircraft and bombers. Today, the Indians, Russians, Chinese, French, British, and Americans are the only powers that host such capabilities, which gives them an edge in mobile deterrence[2].

# Hypersonic missiles and technology

Technology through the twentieth century and the early twenty-first century saw massive leaps forward in missile research & development. The development of rocket and jet engines, in particular, has seen massive change. The V2 missile developed by von Braun recorded maximum speeds of up to 5,760 kmph or Mach 4.6 in the early 1940s. The Soviet R12 missiles which were deployed in Cuba had recorded speeds of up to 12,700 kmph or Mach 10. The Minuteman 3 missile of the United States, which remains in active service today, has recorded a speed of 24,000 kmph or Mach 23. Missile and aerospace propulsion technology reached a point where terminology such as subsonic and supersonic came to be used frequently, to define a vehicle as being slower than the speed of sound and faster than the speed of sound (1235.2 kmph), respectively.

In the last few years, another term has come to tax the minds of military engineers and researchers. Hypersonic aerospace technology enables flight at above Mach 5, within the atmosphere of the Earth (90 km altitude). These vehicles are nimbler compared to traditional ballistic and guided missiles and can manoeuvre to achieve greater accuracy. These characteristics of high speed, manoeuvrability, and unusual altitudes make them both challenging to the best missile defences now envisioned and, until the last minutes of flight, unpredictable as to their targets[3]. There are, as of today, two broad categorisations of hypersonic vehicles[4]:

[2] EurAsian Times Desk. (2018, October 15). India Becomes 6th Country To Have A Fully Operational Nuclear Triad. Retrieved from EurAsian Times: https://eurasiantimes.com/india-becomes-6th-country-fully-operational-nuclear-triad/
[3] Speier, R. H., et al. (2017). Hypersonic Missile Nonproliferation: Hindering the Spread of a New Class of Weapons. Santa Monica, California: Rand Corporation. Retrieved from https://www.rand.org/reports/RR2137.html
[4] Sayler, K. M. (2021). Hypersonic Weapons: Background and Issues for Congress. Washington DC: Congressional Research Service. Retrieved from https://sgp.fas.org/crs/weapons/R45811.pdf

- Hypersonic cruise missiles are powered from launch to target by high-speed, air-breathing engines, or "scramjets" (supersonic combustion ramjets) after acquiring their target.
- Hypersonic glide vehicles are launched by rockets into near space, where they are released and fly to their targets by gliding along the upper atmosphere.

Hypersonic vehicles travel unlike ballistic missiles, and perhaps similar to guided missiles, but with a greater reach, making use of kinetic energy to strike targets with greater impact. Their lower altitude of travel makes them much harder to detect by ground-based radar and other detection systems and sensors. Figure 2 elaborates how terrestrial-based radar detection systems fare off, along with the visual representation of the trajectories of ballistic and hypersonic missiles.

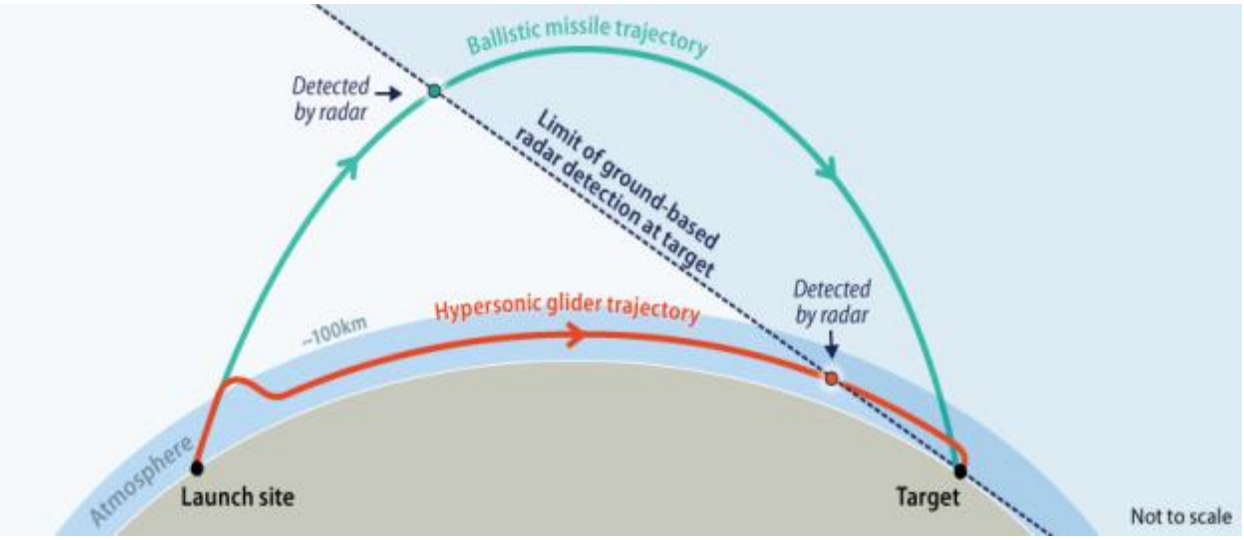


Figure 1: Terrestrial-based detection of ballistic missiles vs hypersonic glide vehicles (Source: CRS)

This is an old yet developed platform. This is because missiles were achieving hypersonic speeds at a very early stage, taking inspiration from the German V2 which would propel the two-stage missile up to the stratosphere and then drop from the sky over targets, achieving tremendous speeds in the descent. However, the hypersonic vehicles of today take a different trajectory (as in Figure 2) achieving maximum stealth and range. A simple explanation would be that the flight path taken by hypersonic vehicles would be more direct and would cover a shorter distance at Mach 5 speed or above. As Vice Chairman of the Joint Chiefs of Staff and former Commander of US Strategic Command General John Hyten has stated, hypersonic weapons could enable "responsive, long-

range, strike options against distant, defended, and/or time-critical threats (such as road-mobile missiles) when other forces are unavailable, denied access, or not preferred"[5].

The evolution of human technology to develop vehicles capable of hypersonic travel is not new, as was stated before. However, the evolution of this specific technology in modern times to support cruise missiles and glider vehicles capable of carrying ordnance are going to further revolutionise modern warfare. The unique military utility that such platforms provide has propelled countries such as Russia, China, the United States and other powers including India to engage in related research and development. Aside from ambitions to acquire offensive hypersonic armament, the pure risk that such platforms afflict to countries with the best of missile defence systems is too high to ignore. As such, countries get pinned down with the looming threats of the security dilemma, forcing them to allocate resources for research and development. A security dilemma – as defined by Kenneth Waltz – is a situation where the actions taken by a state to increase its security cause reactions from other states, which leads to a decrease rather than an increase in the state's security. In this case, an appropriate example would be that the United States has seen a sudden increase in investment in hypersonic R&D due to the increased Russian and Chinese activity in the domain. This paper will now look at the state of research and strides in hypersonic technology by the great powers.

## The Russian Federation

The fall of the USSR, the end of the cold war, and the shattered state of Russia's economy meant that the hypersonic programme, which had its roots in the 1950s, had to be cut off. However, in recent years, Moscow picked up from where it left off and today maintains supremacy in the research and development of hypersonic missile capabilities. Efforts in that direction seem to have gained momentum in Russia with then-President Trump's decision to withdraw from the 1987 Intermediate-Range Nuclear Forces (INF) Treaty, which since its signing had led to the "elimination of 2,692 U.S. and Soviet nuclear and conventional ground-launched ballistic and

[5] US Congress, Senate Committee on Armed Services (2020, February 26). Testimony of John E. Hyten: Hearing on United States Strategic Command and United States Northern Command, Washington DC: US Senate Committee on Armed Services. Retrieved from https://www.armed-services.senate.gov/imo/media/doc/Hyten_02-26-19.pdf.

cruise missiles with ranges between 500 and 5,500 km"[6]. The vehicles and missiles that the Russians are developing far exceed those under development by the Chinese and the Americans, and are also way ahead in the timeline, with fully developed vehicles already in the trials and testing phase.

The Russians have developed a high-end HGV called the "Avangard" (Objekt 4202) which relies upon being launched into the upper atmosphere of the earth through the propulsion of a ballistic missile, to which the HGV is attached. The warhead itself can travel at a speed of Mach 20 to distances beyond 6,000 km in range. After its last successful test in December 2018, President Putin hailed the Avangard as being an "excellent New Year's gift to the nation" which is "invulnerable to intercept by any existing and prospective missile defence means of the potential adversary"[7].

Moscow has also recently tested the 3M22 Zircon hypersonic cruise missile which travels at speeds of up to Mach 6, at a low atmospheric-ballistic trajectory which enables it to penetrate traditional anti-missile defence systems. This poses a major threat to even the most advanced of missile defence systems such as the American Aegis system, which requires at least 8-10 seconds to react, in which time the Zircon can cover over 20 km[8]. This missile can be carried on multiple platforms, including aircraft and naval vessels, increasing the lethality of Russia's aerial and maritime forces in countering their ever-adventurous American counterparts. This shift to hypersonic weapons is likely a means of contending with American superiority in size, technology and the sheer number of aircraft carriers and platforms[9].

[6] Bugos, S. (2019, September 1). U.S. Completes INF Treaty Withdrawal. Retrieved from Arms Control Association: https://www.armscontrol.org/act/2019-09/news/us-completes-inf-treaty-withdrawal
[7] Isachenkov, V. (2018, December 26). Putin oversees hypersonic weapon test, says it's 'invulnerable'. Retrieved from Military Times: https://www.militarytimes.com/news/your-military/2018/12/26/putin-oversees-hypersonic-weapon-test-says-its-invulnerable/
[8] Stilwell, B. (2021). Why Russia's Hypersonic Missiles Can't Be Seen on Radar. Retrieved from Military.com: https://www.military.com/equipment/weapons/why-russias-hypersonic-missiles-cant-be-seen-radar.html
[9] Ibid.

## People's Republic of China

The communist Chinese have been racing to develop their hypersonics programme. Like the object of the programme, the programme itself has achieved great speed, surpassing, as some might suggest, the capabilities of the United States in the field. According to Tong Zhao, a fellow at the Carnegie-Tsinghua Center for Global Policy, "the most important reason to prioritize hypersonic technology development [in China] is the necessity to counter specific security threats from increasingly sophisticated US military technology", such as US missile defences[10]. As was discussed earlier in this paper, the security dilemma created due to the entrance of this new technological platform has forced countries to develop the same to maintain supremacy and eventually deterrence.

In August 2021, China was reported to have conducted tests of a nuclear-capable hypersonic missile that circled the earth before speeding towards its target, demonstrating an advanced space capability that caught US intelligence by surprise[11]. The DF-ZF is a Chinese HGV that is launched into the atmosphere using the DF-17 solid-fuel ballistic missile. The DF-ZF itself is said to be able to reach speeds of between Mach 5 to Mach 10 while gliding, with an estimated range of 2,000 km. This can pose a threat to American assets present in East and Southeast Asia, and beyond if mounted on a missile with greater range such as the DF-21 or DF-31.

## United States of America

Once again, Washington is experiencing a Sputnik-moment: The Russians are far ahead in hypersonics technology, having left the Americans shocked and lagging in yet another technological race. The several departments of the American military apparatus are now funnelling in funds to play catch-up with the Russians and the Chinese. In 2021, the US Department of Defence requested USD 206.8 million for hypersonic defence programs and USD 3.2 billion for hypersonic weapons programs, while in 2022, the DOD requested USD 247.9 million for

[10] Sayler, K. M. (2021). Hypersonic Weapons: Background and Issues for Congress. Washington DC: Congressional Research Service. Retrieved from https://sgp.fas.org/crs/weapons/R45811.pdf
[11] Sevastopulo, D., & Hille, K. (2021, October 17). China tests new space capability with hypersonic missile. Retrieved from Financial Times: https://www.ft.com/content/ba0a3cde-719b-4040-93cb-a486e1f843fb

hypersonic defence programs and USD 3.8 billion for hypersonic weapons programs[12]. The significant investment in offensive capabilities represents once again the need for deterrence against Sino-Russian offensive platforms and the prevalence of the allied security dilemma.

Hypersonics will be essential in fighting and winning the wars of the future, be it in the South China Sea or continental Europe. The Americans, unlike the Russians and the Chinese, will be developing such platforms that will be limited to conventional capabilities, and not nuclear. As of today, the United States does not have any serial-production hypersonic weapon, but has several projects underway across several departments of the Pentagon, including the Army, Navy, Air Force and DARPA. One of the most notable programmes is the Conventional Prompt Strike, which entails the development of a common HGV that can be used across all services. The HGV will be fielded by both Navy and Army, which will each develop service-specific weapon systems and launchers tailored for use from land and sea[13]. The system is intended to have a range of over 2,700 km and provide a "prototype strategic attack weapon system to defeat A2/AD (anti-access, area-denial) capabilities, suppress adversary Long Range Fires, and engage another high payoff/time-sensitive targets"[14]. The US Navy plans on beginning testing of the HGV aboard its Zumwalt-class destroyers by 2025, and the Virginia-class nuclear attack submarines by 2028.

# Conclusion

There are several other countries as well, which are engaging in the development of hypersonics, both due to the fear of its implications as well as to achieve offensive strike capabilities as deterrents. India, Japan and France are among the other countries engaging in such projects, however, not as advanced as those of the three major powers.

[12] Sayler, K. M. (2021). Hypersonic Weapons: Background and Issues for Congress. Washington DC: Congressional Research Service. Retrieved from https://sgp.fas.org/crs/weapons/R45811.pdf

[13] Strategic Systems Programs. (n.d.). Conventional Prompt Strike (CPS). Retrieved from US Navy: https://www.ssp.navy.mil/six_lines_of_business/cps.html

[14] Sayler, K. M. (2021). Hypersonic Weapons: Background and Issues for Congress. Washington DC: Congressional Research Service. Retrieved from https://sgp.fas.org/crs/weapons/R45811.pdf

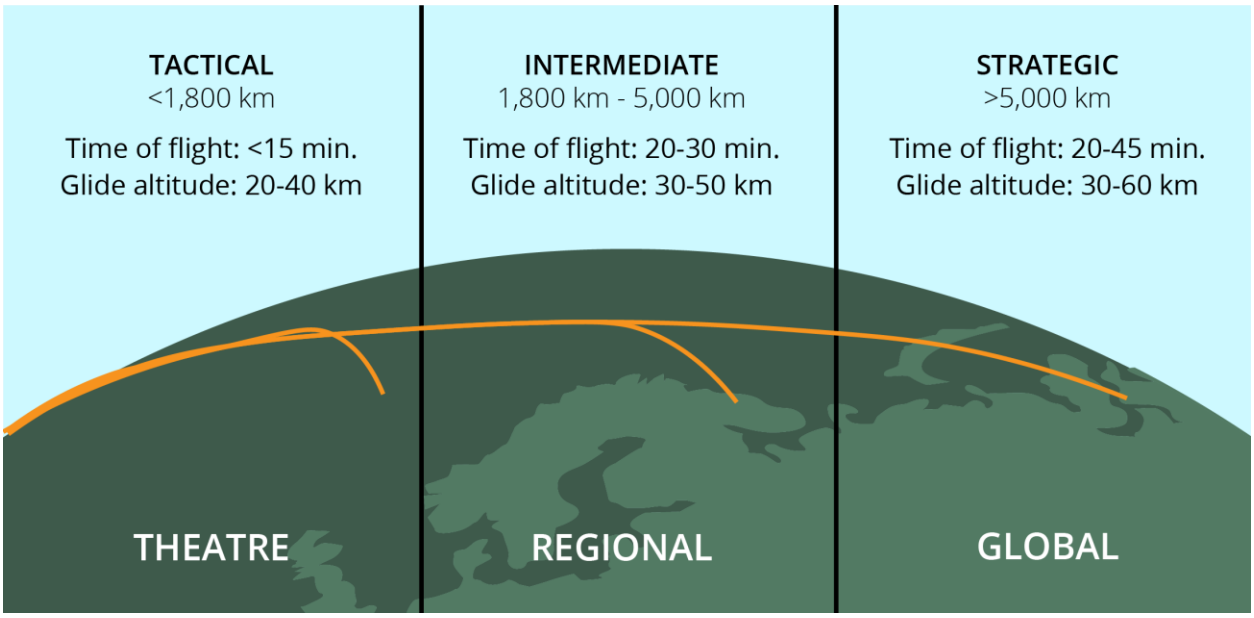


Figure 2: Potential range and timings of hypersonic weaponry showcases the level of threat (Source: Project Ploughshares)

Hypersonic weapons present an existential threat to about any and every country adversarial to the objectives of the operator. Undoubtedly, hypersonic missiles are superior to ballistic and cruise missiles and, in some sense, merge the high-speed and long-range capabilities of ballistic missiles with manoeuvrability and low-flying capabilities of cruise missiles. At sea, hypersonic weaponry can sink entire fleets, with even the most advanced systems (such as Aegis) being unable to cope. The ability to wholly eliminate all known adversarial missile defence systems can pave the way for larger, undeterred strikes on assets and designated targets. Their optimal use can also eliminate the second strike capabilities of the targeted country, with attacks on known silos, and also on mobile launchers. The high manoeuvrability of hypersonic weaponry provides more room for target coordinates to be reprogrammed in real-time. Hence, moving, mobile targets are more likely to be eliminated with such weapons, as compared to convention guided or (even less accurate) ballistic missiles.

The fact that the United States has no serial-production hypersonic weaponry is representative of the fact that it is lagging behind the Russians and the Chinese in the hypersonic race. This will result in a more aggressive and pro-active American threat perception, leading to increased military activities that may potentially cross red-lines as prescribed by adversarial states such as Russia and China. In the short term, this can be a detrimental factor that aggravates the existing

status quo. However, with the progress of time, under the assumption of rational thought on all sides to avoid the break out of hostilities, hypersonics will not prove to be a threat in the long-term, with the development of both offensive platforms for deterrence as well as defensive platforms for countering such weapons. However, the threat of hypersonic weaponry will continue to ensure that we live in a world where there is no prevalent rules-based order. The failure of the United States and Russia to continue the upkeep of the INF treaty is an example of that. In a world struck by the threat of security dilemma, there is only a subsistent, anarchic global disorder.

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